

mented using one or more controllers (e.g., an application specific integrated circuit (“ASIC”), an embedded controller, etc.). The characterization hardware could be controlled, for example, by a microcontroller unit (MCU). Four different architecture options for the characterization hardware **124**, with corresponding components, are discussed below.

**[0041]** One embodiment of the architecture of the characterization hardware **124** is an microcontroller-based architecture. In some embodiments, the microcontroller board can include encoder ports, digital-to-analog (D/A) ports, pulse width modulation (PWM) ports, and universal serial bus (USB) ports. An amplifier is also coupled to the microcontroller board. The microcontroller board can include embedded programming to implement the controlling scheme, a state machine to transfer data to a host computer and/or a driver on the host computer programmed to send/receive data.

**[0042]** Another embodiment of the architecture of the characterization hardware **124** is an xPC based architecture. This architecture uses an xPC configuration and, according to an embodiment of the invention, can include an encoder, digital-to-analog (D/A) and analog-to-digital (A/D) boards and an amplifier. The characterization hardware **124** can also include an encoder board, a D/A board of at least 12 bits, a computer system with appropriate software (e.g., Matlab/Simulink/X Performance characterization (xPC) software), a current amplifier and a second computer to contain the boards and/or the controlling software.

**[0043]** Another embodiment of the architecture of the characterization hardware **124** is an PCI-Based I/O card architecture. This architecture can be integrated in the same computer used for a design studio application discussed above. According to an embodiment of the invention, the architecture can include an I/O peripheral component interconnect (PCI) board including an encoder reading port, A/D and D/A boards, and an 11 bits pulse width modulator. The architecture can further include a custom-made current amplifier to support the D/A or PWM signal and/or programming needed to implement the controller and identification schemes.

**[0044]** Another embodiment of the architecture of the characterization hardware **124** is a real-time workshop with an embedded solution. According to one or more embodiments, a digital signal processing (DSP) kit can be used that uses design and implementation of a controlling board. Other micro-controllers can also be used, which may not require the same amount of design and implementation. These other micro-controllers can, for example, support a way to transfer large amounts of data to the host computer. According to one or more embodiments, Matlab’s real-time workshop (RTW) can be used to perform simulations and generate the embedded code for a DSP or micro-controller. For example, a real-time workshop can be used to make simulations and/or generate embedded code for a DSP or micro-controller board and/or a Micro-controller board, such as, for example, Texas Instruments DSP kit (including controlling board); Motorola DSP kit (including controlling board) and/or a Motorola HC12 micro-controller.

#### CONCLUSION

**[0045]** While various embodiments of the invention have been described above, it should be understood that they have

been presented by way of example only, and not limitation. Thus, the breadth and scope of the invention should not be limited by any of the above-described embodiments, but should be defined only in accordance with the following claims and their equivalents.

**[0046]** The previous description of the embodiments is provided to enable any person skilled in the art to make or use the invention. While the invention has been particularly shown and described with reference to embodiments thereof, it will be understood by those skilled in art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

**[0047]** For example, while each parametric data set is described above as being associated with a single mechanical device, in alternative embodiments, multiple parametric data sets are associated with different operational modes of a single mechanical device.

**[0048]** While some embodiments have been described in the context of rotary switches, other devices, such as window-type toggle switches, levers, and push buttons, can also be characterized and/or simulated using the systems and methods of the invention.

**[0049]** It is possible to create a set of devices that can be attached to a test bed that could be used with the appropriate controllers to characterize other types of mechanical devices/switches. All components described herein as being implemented in software can be implemented in hardware, and all components described as being implemented in hardware can be implemented in software. The presently disclosed embodiments are, therefore, considered in all respects to be illustrative and not restrictive.

#### 1. An apparatus, comprising:

- a characterization module configured to receive data associated with a plurality of operational characteristics of a mechanical device, the plurality of operational characteristics being associated with a perceptual experience of the mechanical device; and

- a conversion module coupled to the characterization module, the conversion module configured to automatically produce, substantially without user intervention, a parametric data set associated with the mechanical device based on the data.

#### 2. The apparatus of claim 1, wherein:

- the data associated with the plurality of operational characteristics of the mechanical device is at least one of analog data and digital data; and

- the parametric data set associated with the mechanical device is digital data.

#### 3. The apparatus of claim 1, further comprising:

- a controller in communication with the conversion module, the controller configured to send a signal to a haptic device based on the parametric data set associated with the mechanical device, the signal operative to output a haptic effect from the haptic device.

#### 4. The apparatus of claim 1, further comprising:

- a design module in communication with the conversion module, the design module configured to modify the parametric data set associated with the mechanical device to produce a modified parametric data set; and